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Production Efficiency on New England Dairy Farms

IV. Adjustments in the Organization of Machinery and Equipment

by

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Preface and Acknowledgement

This bulletin is the fourth in a series concerned with production efficiency on New England dairy farms. In the first bulletin a preliminary appraisal was made of the significant opportunities for reducing costs in dairying. In the second and third bulletins the economies of scale of operations and of the barn-finishing method of harvesting hay, respectively, were analyzed in greater detail. This bulletin deals with the efficient use of machinery and equipment on dairy farms. It emphasizes the economic principles and procedures involved in choosing between alternative methods of doing field work.

The authors are indebted to many farmers and equipment operators in New England who helped to supply the basic information used in the study.

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Adjustments in the Organization of Machinery and Equipment

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Introduction

The trend toward greater substitution of machines for labor to increase output per man and decrease costs of operation has proceeded rapidly on New England dairy farms since the end of World War II. The increase in mechanization raises several problems on these farms. The increasingly larger investment in machinery and equipment means correspondingly high annual costs of ownership of the machinery and equipment for established dairymen. The large capital outlay necessary for the purchase of farm machines is often an important barrier to young people who are interested in starting dairy farming.

Both the increase in numbers of machines and the general rise in prices have increased the value of the machinery on farms. If the equipment on 28 Connecticut farms which were a part of the sample for this study had been bought new at 1949 prices, the investment would have averaged $10,600 per farm, or about $380 per cow. Investment in machinery would equal investment in livestock and it would be about half the investment in land and buildings.

One aspect of the mechanization of dairy farms is the duplication of machines from farm to farm and the small annual use of each machine. Many specialized machines are used for only a few hours in a year.

A tractor-drawn corn planter, for example, costing about $225 with an annual ownership cost of $35 per year, may be used only three or four hours in a year. A baler involves a capital outlay of as much as $2,400 and has an annual ownership cost of about $580, yet it may be used no more than 50 hours in any one year.

Objectives

This study has three objectives:

1. To learn the amount of work done on New England dairy farms with machines in performing field operations, the custom services that are available to farmers for hire, the performance rates of both owned and hired machines, and the charges for different types of custom work.

2. To outline a method of deciding upon the optimum economic organization of machinery for a dairy farm.

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3. To test the opportunities for reducing costs of dairy production and for increasing farm income on a typical small, medium-sized, and large dairy farm by reorganization of owner-operated equipment, by joint ownership patterns, and by more extensive use of custom-operated equipment.

Source of Data

Three farming communities — one each in New Hampshire, Connecticut, and Massachusetts — were selected as representative of New England dairying. Types of farm organizations, size of farm units, and intensity of operations were the criteria used in selecting the areas. Specialized dairy farms predominate in the Lebanon area of Connecticut, less intensive dairy farms in the Ashfield area of Massachusetts, and moderately extensive dairying in the Belmont area of New Hampshire. Records of the farming operations in 1949 were obtained through interviews with all dairy farm operators in each area. In addition, operators of custom farm machinery who did work in these areas were interviewed to obtain information on their operations. These records include the basic data on which the study was developed.

Custom Services

MANY CUSTOM services are available to most New England farmers. Among the reasons for the increase in availability and variety of these services are: (1) the equipment shortage during World War II, including the practice of issuing purchase certificates only to those operators who would agree to make machines available for neighborhood use; (2) technological improvements, especially the rubber tire and hydraulic lift, which have adapted machinery to rapid and easy movement over the highways; and (3) the introduction of specialized, costly machines, such as the pickup baler, field-forage harvester and bulldozer, which are new to many farmers and which require specialized operating and servicing skills.

Types of Custom Operators

Custom work is now done by two major groups of operators. The first group consists of those farmers who want to supplement their income by off-farm work or those who buy a more expensive machine than they feel they can afford for their individual use. The second group is composed of operators who specialize in custom work and do little or no farming. The first group is the most numerous. County agents, machinery dealers, and farmers supplied names of 104 individuals in Connecticut and 46 in New Hampshire who did custom work in 1949, but they indicated that their lists were incomplete. Generally, these farmer operators perform a number of services although they do not supply the highly specialized types of services. The second group is small; only 12 men were listed who could be classified as specialized custom operators and some of them did some farming or were engaged in other business activities such as selling machinery and equipment or operating school-bus routes. But individual operators frequently perform many services or a single service on a large scale.

Specialized custom operators generally indicated that there had been some drop in volume of work since 1946. They attributed this to the wider availability of machinery and the improved financial position of farmers. They indicated that they were planning to adjust to this situation by dropping

certain services which they considered unprofitable. They would either specialize in specific lines or expand into fields in which no services are now available or in which new machinery has recently been introduced.

Custom Services Available

The 60 farmers and 12 specialized custom operators who were interviewed were equipped to perform the 43 different services listed in Table 1.

Table 1. — Types of Custom Services Available in New England in 1949

Land Preparation	Potato dusting	**Land Improvement**
Plowing	Potato spraying	Land clearance
Harrowing	Orchard spraying	Wall removal
Steam sterilization	Cultivating	Stone picking
Fertilizer spreading		Drainage work
Lime spreading	**Crop Harvesting**	Brush plowing
Manure spreading	Mowing hay	Pond digging
Bog harrowing	Raking hay	
	Baling hay	**Miscellaneous**
Crop Planting	Threshing grain	Barn spraying
Tobacco planting	Corn binding	Pumping
Potato planting	Field-chopping hay	Buzz sawing
Corn planting	Stationary chopping	Chain sawing
Bean planting	Potato digging	Snow removal
Grass seeding	Combining grain	Trucking
	Corn picking	Manure loading
Crop Cultivation and Protection	Long-hay loading	
	Baled-hay loading	
Weed spraying		
Corn dusting		

Preparing the land and harvesting the crops were services offered by the greatest number of operators. Field-forage harvesting and weed spraying were undergoing the greatest expansion in 1949. The total quantity of hay baled is steadily increasing. Volume of hay baling per operator appeared to be declining but this probably was due to the increasing number of custom balers available.

The greatest amount of custom work performed in terms of dollar volume was land clearing (bulldozing), which is a very specialized type of work particularly suited to custom operation. Compared to most other jobs, hourly rates are high. Farmers now are especially interested in land-improvement work, partly because of the recent establishment of Soil Conservation Service districts throughout most of New England.

Custom Services Hired

Information obtained in three dairy areas studied indicates the custom services hired by dairy farmers. In Lebanon, Conn., 28 specialized dairy farmers whose milking herds averaged 28 cows paid a total of $9,757 for custom work on 10 operations in 1949 (Table 2). Custom work was done on 683 acres, or about 7 percent of the total acreage on which crop- and land-improvement work in the area was done. Job or equipment hours totaled 912 and total man-hours of labor were 1,112, or slightly less than 7 percent of all man-hours used for crop- and land-improvement work on these farms.

Table 2. — Custom Work Hired for Operations on Crops and Land Improvement by 28 Dairy Farmers in Lebanon, Connecticut, 1949

Job	Number of Farms	Work Performed			Total Charge
		Total Acres	Total Hours	Total Man-hours	
					Dollars
Plow	1	7	15	15	45
Plant corn	9	54	37	37	121
Spray weeds	11	98	39	39	446
Cultivate corn	5	66	52	52	176
Field-forage harvesting	8	45	76	173	1,084
Bale hay	14	308	101	123	2,250
Harvest corn	1	8	8	8	32
Spread lime	3	27	*		58
Spread manure	1	10	10	31	120
Land improving†	20	60	574	634	5,425
Total		683	912	1,112	9,757

*By commercial lime company — no time data available.

†Includes 12 jobs of pond building and wall removal where acreage could not be recorded or estimated.

In the less intensive dairy community of Ashfield, Mass., a total of $2,688 was paid in 1949 for custom services on 9 operations on 23 commercial dairy farms (Table 3). Custom operations were done on 256 acres,

Table 3. — Custom Work Hired for Operations on Crops and Land Improvement by 23 Dairy Farmers in Ashfield, Massachusetts, 1949

Job	Number of Farms	Work Performed			Total Charge
		Total Acres	Total Hours	Total Man-hours	
					Dollars
Plow and harrow	7	41	124	124	367
Bale hay	10	106	53	88	1,462
Fill silo	3		30	42	104
Spread manure	2	17	22	30	66
Mow hay	5	34	27	27	76
Land improving	2	9	33	43	183
Spray orchard	2	44	101	247	346
Haul tobacco	1	3	30	30	60
Set tobacco	1	2	8	8	24
Total		256	428	639	2,688

or 5 percent of the total acreage on which crop- and land-improvement work was performed. The custom work involved 428 job-hours and 639 man-hours of work, which represented about 6 percent of the total man-hours of crop- and land-improvement work performed on these 23 farms.

In the moderately extensive dairy community of Belmont, N. H., a total of $1,203 was spent on custom services for 9 operations during 1949 on 19 commercial dairy farms (Table 4). Work was performed by custom operators on 172 acres, or about 3 percent of the total acreage on which crop-

Table 4. — Custom Work Hired for Operations on Crops and Land Improvement by 19 Dairy Farmers in Belmont, New Hampshire, 1949

Job	Number of Farms	Work Performed			Total Charge
		Total Acres	Total Hours	Total Man-hours	
					Dollars
Plow and harrow	3	10	36	36	90
Mow hay	2	45	37	37	111
Rake hay	1	15	5	5	15
Bale hay	3	36	18	23	217
Harvest long hay	1	15	33	72	132
Fill silo	3	15	40	87	240
Spray orchard	1	16	34	68	53
Spread manure	2	12	40	40	120
Land improving	4	8	30	30	225
Total		172	273	398	1,203

and land-improvement work was done. Custom operations required 273 job-hours and 398 man-hours, which was about 4 percent of the total number of hours required for crop- and land-improvement work on the 19 farms.

If these three groups of farms are an adequate sample of the amount of custom work hired in 1949 for crop- and land-improvement work on New England dairy farms which have herds of more than 10 milking cows, then approximately 560,000 hours of job time and 675,000 man-hours were procured from off the farm by New England commercial dairy farmers.[1] The sample farms hired about $195 worth of custom work per farm in 1949. If this figure is reduced to $150 per dairy farm to offset some of the heavy expense for land-improvement work done on the larger farms in the Lebanon group, it indicates that New England commercial dairy farmers probably hired between 3 and 3.5 million dollars worth of custom work in 1949. The expenditures for custom work by the 37,063 farms of all types which hired some machine work done amounted to 5.6 million dollars in 1949, according to the United States Census of Agriculture, 1950.

Custom Work Performed

Specialized custom operators did a much larger volume of work per operator than individual farmers who performed similar services. Average gross dollar volume in 1949 was about $8,500 for the 12 operators interviewed. Job time per operator was about 1,200 hours annually (Table 5). Income from work done on land clearing and land improvement amounted to about a third of the total gross income. Other jobs performed by this group of operators were not restricted to work on dairy farms. However, a breakdown of jobs performed, acreage of work, and receipts indicates that a major part of the work was done on dairy farms. Harvesting crops and preparation of land were the two leading types of work next to land clearing and improvement work. Only about 7 percent of the receipts of these operators came from miscellaneous sources, such as snow removal or wood saw-

1 The United States Census of Agriculture, 1945, reported 22,454 New England dairy farms on which there were more than 10 milking cows.

Table 5. Volume of Work Performed by 12 Specialized Custom Operators, 1949

	Total Work Performed		Average Work per Operator	
	Crop Work*	All Work	Crop Work	All Work
Number of different kinds of jobs	18	27		
Total acres of work	10,650	11,601†	888	967†
Total job hours of work	8,215	14,651	685	1,221
Total man hours of work	12,188	18,624	1,016	1,552
Total receipts from work	$ 58,694	$102,817	$ 4,891	$ 8,568

*Includes no land-clearing or land-improvement work.

†Acres of work was not reported for 3,049 job hours and $18,549 of receipts. This work included silo filling, a third of the bulldozer work, sawing, trucking, etc.

ing, the kinds of jobs specialized operators like to have to fill in slack time between cropping periods.

Custom services provided by the nonspecialized operators included use of the more common types of farm machinery and the hay baler. Plowing, harrowing, mowing, and baling hay made up the bulk of the work.

Rates of Performance

Rates of performance differ widely among jobs of the same type that are performed under differing field conditions and with different combinations of equipment. The greatest variation in job-performance rates because of equipment combinations was for manure spreading and field-forage harvesting. The number of spreaders used to haul manure from the loader on custom jobs varied from 2 to 5, and the number of trucks used in hauling field-chopper roughage varied from 2 to 4. The greatest variation in job-performance rates because of field conditions was for plowing.

Performance rates of specialized custom operators and farmer custom operators did not differ significantly on those jobs which both performed frequently or on a large scale, such as harrowing, fertilizing, raking, and mowing (Table 6). The widest differences reported was on job hours of time per acre for manure spreading. This was because farmers rarely used more than one spreader at one time on this job.

Price Charged per Acre or per Hour

Prices for custom work are usually quoted on an hourly basis. Jobs customarily quoted otherwise are weed spraying (per acre), baling (per bale), and sawing wood (per cord). The rates usually quoted include the services of the operator, the equipment, and all operating materials such as gasoline, twine, and spray (Table 7). Extra charges are made for additional labor and for supplementary pieces of equipment such as an additional truck in field-forage harvesting or an extra spreader for spreading manure.

Methods Used in Establishing Charges

A few operators were questioned as to their methods of setting rates. Most of them indicated that they tried to establish their prices in line with the usual or competitive price that prevailed in their community. A few said

Table 6. — Typical Rates of Work Performance for Specified Jobs as Reported by Specialized and Farmer Custom Operators, and by Dairy Farmers for Work on Their Own Farms, 1949

Job	Tractor Equipment Furnished by Custom Operator or Used by Farmers		Job Time per Acre			
	Kind	Size	All Custom Operators	Specialized Custom Operators	Farmer Custom Operators	Farmers on Own Farm
			Hours	Hours	Hours	Hours
Plow old ground	1-bottom plow	16-inch	2.0	1.9	2.0	2.4
	2-bottom plow	14-inch	1.0	.9	1.0	1.3
	2-bottom plow	16-inch	.8	.8	.8	1.0
Plow sod ground	1-bottom plow	16-inch	3.0	2.9	3.0	3.0
	2-bottom plow	14-inch	1.5	1.5	1.5	
	2-bottom plow	16-inch	1.2	1.1	1.2	1.3
Spread fertilizer	1 spreader	8-foot	1.0	.7	1.0	1.0
Spread manure	1 spreader	70-bushel	1.6*	1.6*	1.6*	3.3
	2 spreaders	701bushel	.9*	.8*	.9*	
Harrow	Disk harrow	7-foot	1.0†	1.0†	1.0†	1.2†
Seed grass	Broadcast	8-foot	.2	.1	.3	.4
Seed small grain	Single disk	8-foot, 16-6	.6	.6	.6	.8
Plant corn	Corn planter	2-row	.8	.7	.8	1.0
Cultivate corn	Cultivator	2-row	.8	.7	.8	.8
Spray weeds	Sprayer	18-foot boom	.3	.3	.4	
Mow hay	Mower	7-foot bar	.6	.6	.7	.7
Rake hay	Side delivery rake	9-foot	.6	.5	.6	.6
Bale hay	1-man pickup baler	Medium	.4	.4	.4	.6
Field chop hay or grass silage	Chopper, blower and 1 truck	Large chopper 1½-ton truck	.9	.8	.9	1.2
	Chopper, blower and 2 trucks	1½-ton truck	.7	.6	.7	.9
	Chopper, blower and 3 trucks	1½-ton truck	.5	.4	.5	
Field forage harvest corn silage	Harvester, blower and 2 trucks	Large harvester 1½-ton truck	1.3	1.3		
Harvest corn silage	Binder, ensilage cutter, 2 wagons	1-row				13.5
Harvest grain	Combine harvester	6-foot	1.3	1.3	1.3	
Harvest corn	Corn picker	1-row	1.2	1.2	1.2	
Land improving	Crawler tractor and dozer	Large	5.0	5.0		

*Based on 8-10 loads per acre with the farmer helping with the loading.

†Once over with one-half lap.

Table 7. — Typical Prices Charged for Specified Jobs as Reported by All Custom Operators, 1949

Job	Tractor Equipment Furnished by Custom Operator		Price Charged*	
	Kind	Size	Per Hour	Per Acre
			Dollars	Dollars
Plow old ground	1-bottom plow	16-inch	3.00	6.00
	2-bottom plow	14-inch	3.50	3.50
	2-bottom plow	16-inch	4.50	3.60
Plow sod ground	1-bottom plow	16-inch	3.00	9.00
	2-bottom plow	14-inch	3.50	5.25
	2-bottom plow	16-inch	4.50	5.40
Spread fertilizer	1 spreader	8-foot	3.25	3.25
Spread manure	1 spreader	70-bushel	4.00	6.40
	2 spreaders	70-bushel	10.00	9.00
Harrow	Disk harrow	7-foot	3.00	3.00
Seed grass	Broadcast	8-foot	4.00	0.80
Seed small grain	Single disk	8-foot, 16-6	3.25	1.95
Plant corn	Corn planter	2-row	3.50	2.80
Cultivate corn	Cultivator	2-row	3.00	2.40
Spray weeds	Sprayer	18-foot boom	16.00†	4.80†
Mow hay	Mower	7-foot bar	3.50	2.10
Rake hay	Side delivery rake	9-foot	3.25	1.95
Bale hay	1-man pickup baler	Medium	19.50‡	7.80‡
Field crop hay or grass silage	Chopper and blower	Large chopper	10.00	
	Chopper, blower and 1 truck	1½-ton truck	13.00§	11.70§
	Chopper, blower and 2 trucks	1½-ton truck	16.00§	11.20§
	Chopper, blower and 3 trucks	1½-ton truck	19.00§	9.50§
Field forage harvest corn silage	Harvester, blower and 2 trucks	Large harvester 1½-ton truck	19.00§	24.70§
Harvest grain	Combine harvester	6-foot	7.00||	9.10||
Harvest corn	Corn picker	1-row	4.75	5.70
Land improving	Crawler tractor and dozer	Large	8.50	42.50

*Includes medium-sized tractor, specified tractor equipment, fuel, and operator of tractor, except as otherwise indicated.

†Includes spray material.

‡Based on a yield of 1½ tons and a charge of $0.14 per bale. At a yield of 2 tons per acre, the price charged per hour was $26.25 and the price charged per acre was $10.50.

§Farmer furnishing 1 tractor and 1 man.

|| Includes 2 men.

they set their prices on the basis of what they would be willing to pay for the same services. Detailed cost analyses apparently had little part in establishing the rates charged. As would be expected from these types of rate-setting principles, the prices charged by custom operators varied considerably.

The distance to and the size of the job were factors in the price charged. Most operators made no charge for travel time within their immediate neighborhood. Some, however, charged for the total time going from and returning to their headquarters; others charged for travel time only one way. Some raised their hourly rates for the more distant jobs to compensate for the greater travel time. Jobs requiring less than a half day are frequently priced at a higher rate than jobs that involve more time.

Method of Determining an Economic Organization of Machinery and Equipment

Arriving at the optimum economic pattern of machines and of their ownership for a farm involves evaluation of the work load for the specific jobs to be done and the capacity of various types and sizes of machines for performing the jobs within the seasonal time for the work. Having chosen the alternative machines and combinations of machines from the view of physical production, the next step is to compute the machine and labor costs for each combination to arrive at the least-cost combination for the particular farm.

Machinery and Labor Costs

Annual ownership costs include interest on investment, taxes, fire insurance, housing, and that part of depreciation that is associated with age and obsolescence of the machine. In general, ownership costs per year for farm machines are 10 to 15 percent of the purchase price of new machines. Power-take-off and auxiliary engine-driven machines have the higher annual cost rate. Table 8 shows annual ownership charges for some of the more important farm machines. Depreciation, as a part of ownership costs, is figured on the basis of a useful life of from 8 to 13 years, depending on the amount of use of the machine. If a machine is used many hours each year it probably wears out before it depreciates through obsolescence; if it is used only a few hours, time depreciation alone is important. Interest is computed at the rate of 4 percent, taxes at the rate of 20 mills (2 percent) and fire insurance at the rate of $7.50 per $1,000 (0.75 percent) on half the original investment. Housing varies from $2.00 to $6.00 a year, depending on the size of the machine.

Direct operating costs vary with the amount of use of a machine. These costs include such items as gas, oil, grease, twine, spray materials, repairs, and, as indicated previously, that part of the depreciation due only to use of the machine.[2] The bulk of New England farm machinery is seldom used enough each year to depreciate from use. A charge for wear depreciation is

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2 For a discussion of "time depreciation" and "wear depreciation" see O. J. Scoville, "Fixed and Variable Elements in the Calculation of Machine Depreciation", *Agricultural Economics Research* Vol. 1, Number 3, Bureau of Agricultural Economics, USDA, July, 1949.

Table 8. — Prices and Annual Fixed Ownership Costs for Equipment, 1949

Machine	Size	Type	Price at Local Dealer	Depreciation*	Other Costs†	Total Annual Ownership
			Dollars	Dollars	Dollars	Dollars
Plow, 2-way	1 16-inch	Tractor mount	200	16.67	10.75	27
Plow, 1-way	2 14-inch	Tractor mount	160	13.33	9.40	23
Plow, 1-way	2 16-inch	Sulky	200	16.67	10.75	27
Fertilizer spreader	8-foot	Sulky	150	12.50	9.05	22
Lime spreader	8-foot	Sulky	150	12.50	9.05	22
Manure spreader	70-bushel	2-wheel trailer	375	46.88	18.65	66
Disk harrow	7-foot	18-inch disk	200	16.67	12.75	29
Grass seeder	8-foot	Broadcast	175	9.72	9.90	20
Grain drill	8-foot	Single disk	420	23.33	18.35	42
Corn planter	2-row	Fert. attachment	225	12.50	9.60	22
Corn cultivator	2-row	Tractor mount	225	18.75	9.60	28
Weed sprayer	18-foot	Tractor mount	275	34.38	13.30	48
Mower	7-foot	Tractor mount	250	20.83	12.45	33
Side delivery rake	9-foot	Heavy duty	300	25.00	16.10	41
Hay loader	Standard	Heavy duty	325	27.08	16.95	44
Bale loader	Standard	Traction drive	400	33.33	19.50	53
Baler, 1-man pickup	Medium	Auxiliary engine	2,400	300.00	87.00	387
Field forage harvest	Large	Auxiliary engine	2,400	300.00	87.00	387
Blower	10-inch	Auger feed	275	22.92	13.30	36
Elevator	40-foot	Double chain	450	32.14	21.19	53
Corn binder	1-row	Power-take-off	750	41.67	31.31	73
Ensilage cutter	14-inch	Standard	490	40.83	22.54	63
Truck	½-ton	Pickup	1,450	120.83	54.94	176
Truck	1½-ton	Platform body	2,000	166.67	73.50	240
Truck	3-ton	Platform body	3,700	316.67	134.25	451
Wagon	1-ton	2-wheel trailer	175	9.72	9.91	20
Wagon	2-ton	4-wheel trailer	250	13.89	14.44	28
Combine harvester	6-foot	Auxiliary engine	1,800	150.00	66.75	217
Corn picker	1-row	Sulky	900	75.00	34.40	109
Wood saw	30-inch	Table saw	85	4.72	4.65	9
Tractor	Small	Tricycle	1,400	116.67	53.25	170
Tractor	Medium	Tricycle	1,800	150.00	66.75	217
Tractor	Large	Tricycle	2,200	183.33	80.25	264
Auxiliary engine	15-H.P.	4 cylinder	350	30.43	15.12	46

*Age and obsolescence depreciation only, figured on a useful life varying from 8 to 18 years.

†Includes: interest at 4 percent on half the original investment; taxes at 20 mills on half the original investment; fire insurance at $7.50 per $1,000 on half the original investment; and housing at $2.00 to $6.00, depending on the size of the machine.

not made for simple equipment operated at slow speeds, unless the machine is used 300 or more hours per year. The more complicated, high-speed machines must be used about 500 hours a year before a charge for wear depreciation is made. Above these hours of annual use the charge per hour for wear depreciation varies somewhat within each of these two groups of ma-

chines, but it averages about 10 cents an hour for the relatively slow machines and 50 cents an hour for the more complicated, high-speed machines. Typical direct operating costs which include wear depreciation are given in Table 9 for the more important machines.

Table 9. — Typical Direct Operating Costs, 1949

Machine	Size	Cost per Hour*		
		Annual Use in Hours		
		1-299	300-499	500 and More
		Dollars	Dollars	Dollars
Plow, 2-way	1-bottom, 16-inch	.06	.13	.13
Plow, 1-way	2-bottom, 14-inch	.06	.14	.14
Plow, 1-way	2-bottom, 16-inch	.06	.14	.14
Fertilizer spreader	8-foot	.06	.10	.10
Lime spreader	8-foot	.06	.10	.10
Manure spreader	70-bushel	.07	.19	.19
Disk harrow	7-foot	.07	.15	.15
Grass seeder	8-foot	.06	.10	.10
Grain drill	8-foot, 16-6	.06	.14	.14
Corn planter	2-row	.06	.10	.10
Corn cultivator	2-row	.06	.13	.13
Weed sprayer	18-foot	3.80	3.91	3.91
Mower	7-foot	.11	.19	.19
Side delivery rake	9-foot	.11	.19	.19
Hay loader	Standard	.06	.17	.17
Bale loader	Standard	.06	.16	.16
Baler, 1-man pickup	Medium	4.20	4.20	4.80
Field forage harvester	Large	.45	.45	1.05
Blower	10-inch	.06	.13	.13
Elevator	40-foot	.15	.23	.23
Corn binder	1-row	.07	.22	.22
Ensilage cutter	12-inch	.06	.18	.18
Truck	½-ton	.90	.90	1.19
Truck	1½-ton	1.10	1.10	1.50
Truck	3-ton	1.80	1.80	2.56
Wagon	1-ton	.06	.09	.09
Wagon	2-ton	.06	.10	.10
Combine harvester	6-foot	.12	.57	.57
Corn picker	1-row	.11	.33	.33
Wood saw	30-inch	.06	.07	.07
Tractor	Small	.40	.40	.57
Tractor	Medium	.50	.50	.72
Tractor	Large	.60	.60	.88
Auxiliary engine	15-H.P.	.40	.40	.57

*Includes repairs, spray materials, twine, grease, oil, gas, and wear depreciation wherever applicable. A charge for liability insurance was not included as it pertains mostly to doing custom work off the farm and cost is related to receipts from custom work.

In determining the optimum combination of machinery, the labor used to operate or service the machinery and equipment represents a real cost if it is hired or if it is family labor for which there are alternative uses on the farm. In general, the more scarce and therefore the higher priced farm labor becomes the more profitable it is to substitute machinery for labor, and to choose the correct machine for a particular job.

Machinery Ownership Patterns

The most economic organization of machinery for a specific farm is further influenced by the relative cost of alternative ownership patterns. If it costs less to hire the services of a machine than to own and operate the machine, ownership by the farm operator may not be desirable. A discussion of the alternative ways in which a dairyman can obtain the services of the machines needed in his farming operation is the major theme of this bulletin.

The five alternative patterns of machinery ownership studied were as follows:

1. Self-owned equipment.
2. Joint-owned equipment.
3. Custom-hired equipment.
4. A combination of self-owned and custom-hired equipment.
5. A combination of self-owned equipment, custom-hired equipment, and custom work off the farm.

Self-ownership has the obvious advantage of having all production equipment readily available to complete the job in as timely a fashion as the performance rate of the machinery will permit. But it requires control of considerable capital for investment in machinery and equipment. Also, all ownership and operating costs associated with the machinery must be carried by the individual farm business.

Joint ownership of farm machinery by two or more farmers is one way to reduce machinery costs for a single farm. One corn planter, plow, lime spreader, or other such machine can readily do the work on two or more farms. If jointly owned, the capital investment and annual ownership costs would be divided between the cooperators. But this type of ownership is not common in New England. Apparently other problems associated with cooperative ownership and use of farm machines more than offset any economic advantages, except for a few farm operators who have special ties or aptitudes for cooperating.

Use of custom services is much more common than joint ownership. It eliminates, by a payment for the service, many of the strains which joint ownership imposes on personal relationships between farmers. Although it still requires cooperation between the hiring farmer and the custom operator who may be a neighboring farmer, this type of cooperation is easier to obtain and the working relationships appear to be more satisfactory for a larger number of farmers. In other words, custom hiring provides a method of reducing machinery costs under certain conditions for a large number of farmers.

Problems of Comparison of Costs for Owned and Custom-hired Machines

Using custom services presents problems that are associated with the decision as to when to own or when to hire. The time required to do the job

may vary as between custom-hired and self-owned equipment, as shown in Table 6. But the major problem when comparisons are made between substitution of custom services for self-performed work has to do with estimation of costs.

In comparing the costs of owning equipment or of hiring work done, only machines that do the same type of work and produce the same quality product should be compared. For example, comparing the cost of owning a hay baler with the cost of hiring a field-forage harvester for making grass silage is not sufficient, because the choice between these two machines involves the whole question of the economy of grass silage versus field-cured hay. To obtain a correct comparison, some consideration must be given to the change in income that is directly attributable to the change in product.

In making the decision as to whether to buy labor-saving machinery or to hire the job done with similar equipment, the annual ownership costs of power equipment such as tractors or trucks generally are not considered. The reason for this is that tractors and trucks are usually retained on farms regardless of the quantity of work custom hired. The annual ownership cost of a tractor is a fixed farm expense. The addition or elimination of one job does not change the ownership cost of the tractor, which must remain on the farm for other uses. But suppose a farmer is considering whether to own or to hire a field-forage harvester, in which the "bundle" of equipment involves a second tractor or truck to be used only with the harvester. In this case the fixed costs of the additional power would be allocated to the single job. Under these circumstances, one cost of doing the job with his own equipment would be the fixed ownership cost of the additional power equipment. Another and more obvious situation in which this principle would not apply would be the case in which all jobs are custom hired. Under these conditions all units of power could be disinvested along with the machinery, which would be custom hired.

When a farmer buys labor-saving equipment or custom hires his job done, farm labor is usually freed from that particular job and is thus available for other uses. If this labor can be put to productive use or if it can be removed from the payroll, as in the case of day labor, then some price must be placed on it. In actual practice, custom hiring frequently frees only the labor of one man and then only for part of a day. Hence making a quick adjustment in the farm business to absorb profitably this limited amount of labor is difficult. If a farmer can make up productive use of small amounts of free time, a zero value should be placed on such labor. But if the labor can be used profitably the procedure recommended is to value the freed labor at the approximate community wage rate or at about $1.00 an hour.

In summary, the information that should be assembled for making a decision as to whether to own or to hire a machine is as follows: (1) the amount of work to be done, (2) the performance rate of the machines (similar to that shown in Table 6), (3) the price changed by the custom operator (similar to that shown in Table 7), (4) the annual fixed cost of owning the machine (similar to that shown in Table 8), (5) the direct operating costs to the farmer who performs the job (similar to that shown in Table 9), and (6) the value of the labor saved.[3]

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3 G. E. Frick and S. B. Weeks, *When to Hire and When to Own Farm Equipment on New England Dairy Farms*, New Hampshire Agr. Ext. Serv., Ext. Cir. 302 (1951).

Problems in Computing Costs of Providing Custom Equipment for Hire

Farmers need the type of information outlined above if they are to appraise the pricing of custom services. Direct operating costs, annual costs of ownership, costs of labor, and the performance rate for the machine in question must be considered in order to establish the correct charge on an hourly rate.

The charge per hour made by the farmer custom operator must return to him enough money to pay for direct operating expenses, such as gas, oil, and grease. In addition, a charge for labor must usually be made as the costs of doing custom work off the farm include the loss of income that might have been earned on the farm.[4] Therefore, the rate charged should be approximately in line with the earning capacity of labor when used for the farm business.

Conversely, as in custom hiring, no annual ownership costs usually need to be assigned to units of power, such as tractors or trucks used in doing custom work. These units usually must be maintained on the farm even if custom work is not performed. But if it is necessary to buy an additional truck or tractor exclusively for custom work, the ownership costs should be charged to the custom service.

Liability insurance is a small but advisable expense associated with doing off-farm work. A general policy covering personal liability for all home-farm operations must be bought in order to have coverage for custom work. The costs and benefits of the general policy relate to all farm operations. For that reason, the cost of the general policy — the fixed ownership aspect — cannot be considered as a machinery cost but rather as one of the entire farm. Only that part of insurance cost which covers custom work specificially is an operating cost. The amount paid for this coverage is small (about $0.50 per $100.00 of custom-work receipts) and it varies with the kind of machine, the amount of use, and the price charged per hour. Hence the direct operating cost per hour was not calculated here. But liability insurance is a small expense that should be considered when doing custom work.

In the setting of prices for services performed, the specialized custom operator and the individual farmer doing limited custom work differ. This is mainly because of the different cost position each occupies. A full-time or specialized custom operation must cover all his fixed costs of operation, such as depreciation, housing, taxes, and repairs. He must also pay for his direct operating costs of fuel, materials, and labor. In addition, he must receive some pay for himself as manager and interest on his investment in equipment. Any earnings left above these charges would be profit. An individual farmer, however, has only to charge a minimum price for custom work equal to the direct operating costs and the extra labor expense. Any returns above this minimum level of direct operating costs will represent a payment toward the fixed costs already incurred and borne by the farm business. Any payment toward these fixed costs, which is earned by custom work, is more than would have been obtained had no custom work been done.

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4 S. B. Weeks and G. E. Frick, *How to Make Money Doing Custom Work*, New Hampshire Agr. Ext. Serv., Ext. Cir. 303 (1951).

Integrated Machinery and Other Resources on Typical Dairy Farms

FARMING IS A complex business in which the various resources and techniques used in production must be properly combined to produce the greatest satisfaction for the farm family. This goal may consist either of obtaining a maximum net farm income or a somewhat smaller income with more free time for the farmer and the elimination of hard work. Several alternative organizations of machinery are tested from these two viewpoints, although major emphasis is on ascertaining combinations of machinery that will maximize net farm income. Certain combinations of machines which are efficient in terms of completing work requirements speedily and easily are costly to own and operate.

We now proceed with an economic appraisal of alternative adjustments of machinery and equipment that could be incorporated in the organization of typical farms described in an earlier report of this series.[5] These dairy farms are representative of 1-, 2-, and 3-man operating units. In terms of size of herd, they represent farms with 10-14, 25-29, and 35-39 cows, respectively. Sixty-seven percent of all commercial dairy herds in New England fall within this range of 10 to 39 cows.

In the earlier report selected adjustments were made in the organization and management of crop and livestock production on these dairy farms to suggest and test some types of changes which operators of similar farms might consider, and to demonstrate a method of estimating changes in costs and returns. The adjustments were evaluated within a framework of specified physical input-output relationships, assumed prices for inputs and outputs, and the pattern of family ownership of productive resources that is common to the area.

The effect of new technology upon production efficiency was demonstrated by showing the charactertistics of the farm business before and after changes were made and by estimating the change in net farm income through the use of a farm budget. The budget or farm plan is the best method for measuring the impact of specific adjustments on an individual farm. It is recognized that adapting specific practices to a given farm may encounter rigidities that will limit over-all recommendations. But the analysis for typical farm situations indicates the desirable direction of change.

In the following sections of this bulletin the monetary and nonmonetary effects for several alternative patterns of machinery are appraised from the view point of their use on these farms. Full ownership of cropping equipment by the operator, joint ownership by two or more operators, hiring all cropping work performed by custom operators, and combinations of ownership and custom hiring are the alternatives considered. All other phases of the farm business are the same as set forth in the previous report.

Farm A — A Small Dairy Farm

As usually operated, farm A carries 14 cows, 3 heifers each more than a year old, 4 heifer calves, and a family flock of chickens. The combination of equipment is built around a small tractor and low-bed wagon for hauling

5 I. F. Fellows, G. E. Frick, and S. B. Weeks, *Production Efficiency on New England Dairy Farms, 1. Preliminary Appraisal of Cost Reduction Opportunities,* Storrs, Conn. Agr. Exp. Sta. Bull. 283 (1952).

hay and corn. The farm truck is the half-ton pick-up type. Cropland consists of 34 acres; 5 in corn silage, 2 in new seeding, and 27 in mixed hay. There are 50 acres of permanent pasture and pastured woods.

In the reorganization of this farm, in the earlier report, adjustments were limited largely to more cows, more fertilizer materials, and barn finishing of hay. The acreage in the farm and the labor force are adequate when used more effectively. A small additional investment in buildings would be required. Output of both crops and livestock would reflect improved management in the many phases of the production process. Table 10 summarizes the proposed crop and livestock organization for farm A as developed in the previous study in this series.

Table 10. — Suggested Crop and Livestock Organization of Farm A, a Typical, Small New England Dairy Farm

Crop	Acres	Production in Tons of Hay Equivalent
Corn silage	5	25
Ladino-Brome hay:		
2 cuttings	14	50
1 cutting	10	
New seeding	5	13
Aftermath grazing	(24)	13
Permanent pasture	30	30
Total	64	131

Livestock	Number	Production	
Cows	18	Milk produced	125,000 lbs.
Heifers, 1 year+	4	Cows sold	4 head
Heifer calves	4	Calves	10 head

This revised cropping and livestock plan is used in this study as a base to test alternative patterns of machinery organization. As the major emphasis is on adjustment of machinery to this revised farm business, only these aspects of the farm business that are associated with the use of machinery and equipment are analyzed in detail. Estimates are made of the influences of alternative equipment patterns upon additional farm costs and farm returns.

The cropping operations, broken down by jobs, crop acres, and acres of work, are shown in Table 11.

Table 11. — Annual Acreage Associated with Cropping Operations, Farm A

Operation	Acres of Land	Acres of Work
Plowing	10	10
Harrowing	10	20
Planting corn	5	5
Cultivating corn	5	20
Spreading manure	22	22
Spreading fertilizer and lime	41	41
Seeding grass	5	5
Harvesting hay	24	38
Harvesting corn silage	5	5
Pasture maintenance	30	30

Alternative 1 — Recommended Combination of Self-owned Equipment

Although this one-man farm has a small workload for machines, it has essentially the same jobs to be done as do the larger dairy farms in the area (Table 12). The operator of farm A is faced with the problem of getting all these jobs done properly and on time without incurring larger fixed costs than can be met from his small volume of business. To handle the workload with his own equipment means that he must have a substantial inventory of tillage, planting, and harvesting equipment, as well as power units and miscellaneous items. The list of machines in Table 12 represents the optimum combination of mechanical powered machinery that would meet the functional requirements of the cropping program with the available labor supply. Direct operating costs of this combination of machinery with no charge for labor would amount roughly to $179 a year and total machinery costs would amount to $950 a year.

Alternative 2 — Joint Ownership

Joint ownership, as an alternative machinery ownership pattern, might not influence operating costs but it would materially reduce the fixed-ownership charges that must be carried by each farm operator. For example, assuming that the machinery investment, except that for the farm truck and hay-unloading equipment, can be carried equally by two farms, annual ownership and operating charges exclusive of labor would be reduced from $950 to about $593.

This example indicates the type of adjustment in costs that would result from joint ownership of cropping equipment. But not enough farmers have shared ownership of machines to provide data on cost characteristics for an evaluation of this alternative ownership pattern. Operating costs might be increased by additional travel for the equipment, by less complete control over maintenance by either operator, by depreciation because of wear, and similar disadvantages. The quality of the product might also be influenced adversely by these factors. An evaluation of this alternative, as an opportunity to reduce production costs, must be related to the particular circumstances that accompany each situation.

Alternative 3 — Substitution of Custom-hired for Self-owned Machinery

The organization of machinery on farm A was analyzed to determine the economies that might be brought about by substituting custom-hired for self-owned equipment in all field operations. It did not appear feasible to include general power and transportation work. The costs for custom-hired services shown in Table 13 are based on the workload for farm A shown in Table 11 and the prices charged by custom operators as shown in Table 7. The total cost of hiring the cropping operations would be $1,480, which would be $530 more than the ownership and operating costs for owned machinery if no charge is made for labor of the farm operator (Table 16). But if his labor were valued at $1.00 an hour and freed hired labor were not released, it would cost only $4 more to custom-hire all crop work than to do it with owned machinery. This small change in total cost would affect unit production costs very little and net farm income would be reduced by $4

Table 12. — Investment, Costs, and Time Requirements for a Recommended Combination of Owned Cropping Machinery for Farm A When All Work Is Self-performed.

Operation	Machines		Hours of Machine Operation	Man-hours of Operating Labor	Price at Local Dealer	Ownership Costs	Total Ownership and Operating Costs with Specified Value per Hour for Labor*	
	Number and Kind	Size					None	$1.00
			Hours	Hours	Dollars	Dollars	Dollars	Dollars
Plowing	1 plow, 2-way	16-inch	30	30	200	27	41	71
Harrowing	1 disk harrow	7-foot	24	24	200	29	40	64
Planting corn	1 planter	2-row	5	5	225	22	24	29
Cultivating corn	1 cultivator	2-row	16	16	225	28	35	51
Spreading manure	1 spreader	70-bu.	22	73	375	66	76	149
Spreading fertilizer and lime	1 spreader	8-foot	33	41	150	22	37	78
Seeding grass	1 grass seeder	8-foot	2	2	175	20	21	23
Harvesting hay	1 mower	7-foot	27	27	250	33	47	74
	1 S.D. rake	9-foot	23	23	300	41	53	76
	1 loader	Standard	49	99	325	44	69	168
	1 wagon	4-wheel			†	†		
	1 fork, hoist	Standard	8	38	125	14	17	55
Harvesting corn silage	1 corn binder	1-row	10	12	750	73	78	90
	1 ensilage cutter	12-inch	15	16	490	63	116	132
	1 aux. engine	15-H.P.			350	46		
	1 wagon	4 wheel	10	40	†	†	5	45
Pasture maintenance	1 drag	Brush	6	6		1	3	9
	1 mower	7-foot	14	14	‡	‡	7	21
General power and transportation	1 wagon	4-wheel			250	28	28	28
	1 tractor	Small	30	30	1400†	170†	182	212
	1 truck	½-ton	30	30	1450	44§	71	101
Total			354	526	7240	771	950	1476

*Includes operating cost of tractor for all tractor-powered machines.
†Price and ownership costs of the wagon and tractor are not allocated to the various crop operations.
‡Price and ownership costs of the mower are included with the hay-harvesting operation.
§The half-ton truck has many noncrop farm uses. Therefore, 25 percent of the ownership cost was allocated to crop work.

Table 13. — Equipment Combination and Annual Cash Costs for Custom Services When All Cropping Operations Are Hired, Farm A

Operation	Machines: Number and Kind	Machines: Size	Hours of Operation	Price Charged per Hour	Annual Cash Cost
			Hours	Dollars	Dollars
Plowing	1 2-bottom plow	14-inch	15	3.50	52
Harrowing	1 disk harrow	7-foot	20	3.00	60
Planting corn	1 planter	2-row	4	3.50	14
Cultivating corn	1 cultivator	2-row	16	3.00	48
Spreading manure	2 spreaders	70-bu.	18	10.00	180
Spreading fertilizer and lime	1 spreader	8-foot	41	3.25	133
Seeding grass	1 grass seeder	8-foot	1	4.00	4
Harvesting hay	1 mower	7-foot	23	3.50	80
	1 S.D. rake	9-foot	23	3.25	75
	1 baler	Medium	15	26.25	394
	1 bale loader	Traction	19	8.00	157
	1 truck	1½-ton			
	1 bale elevator	Chain	15	5.75	86
Harvesting corn silage	1 forage harvester	Large	7	20.00	140
	1 tractor and blower	Large Auger			
	2 trucks	1½-ton			
Pasture maintenance	1 drag	Brush	6	2.50	15
	1 mower	7-foot	12	3.50	42
Total			235		1480

(Table 17).[6] In either case, substitution of custom machinery would relieve the farm operator of a capital investment of about $7,240 for cropping machinery on the basis of 1949 prices for new equipment. If capital reserve or credit were a problem in reorganizing farm A or getting started in farming under similar conditions, substitution of custom equipment might be advisable even though more costly on an annual basis.

Alternative 4 — Partly Owned and Partly Hired

Where, as on farm A, annual use of some machines is limited to a few hours, it is often less expensive to obtain the use of these machines on a custom basis than to own them. On farm A, if there were no alternative use for labor so that there would be no value placed on the labor freed by cus-

6 If hired labor freed by the hiring of custom services could be released, it would cost $92 less to custom-hire all crop work than to do it with owned machinery. The cost of producing 100 pounds of milk would be reduced by $0.07. Net farm income on this farm would remain the same whether or not the labor was used on the farm or released.

tom work, it would be profitable to custom-hire corn planting, grass seeding, and corn harvesting. Total costs for owning and operating other cropping machinery and for the custom work hired would be $861 per year compared with $950 if all the machines were owned (Tables 12 and 14). Capital invested in cropping machinery would be reduced by about 27 percent.

Table 14. — Equipment Combination and Annual Cash Costs for Equipment Services When Part of the Cropping Equipment Is Owned and Part Is Hired, Assuming Farm Labor Is Not a Cost, Farm A

Operation	Machines		Method of Acquiring Service	Annual Cash Cost
	Number and Kind	Size		
				Dollars
Plowing	1 plow, 2-way	16-inch	Own	41
Harrowing	1 disk harrow	7-foot	Own	40
Planting corn	1 planter	2-row	Custom	14
Cultivating corn	1 cultivator	2-row	Own	35
Spreading manure	1 spreader	70-bu.	Own	76
Spreading fertilizer and lime	1 spreader	8-foot	Own	37
Seeding grass	1 grass seeder	8-foot	Custom	4
Harvesting hay	1 mower	7-foot	Own	47
	1 S.D. rake	9-foot	Own	53
	1 loader and wagon	Standard	Own	69
		4-wheel	Own	
	1 fork, hoist	Standard	Own	17
Harvesting corn silage	1 forage harvester and tractor	Large	Custom	133
		Medium	Custom	
	2 trucks	1½-ton	Custom	
	1 blower and tractor	Auger	Custom	
		Small	Own	4
Pasture maintenance	1 drag	Brush	Own	3
	1 mower	7-foot	Own	7
General power and transportation	1 tractor	Small	Own	182
	1 truck	½-ton	Own	71
	1 wagon	4-wheel	Own	28
Total				861

The corn planter, grass seeder, corn binder, ensilage cutter, and auxiliary power unit, the new prices of which total $1,990, could be disinvested, or not purchased, depending on the circumstances.

If there were some alternative uses for the labor on farm A, the situation would differ and more jobs could be profitably hired. Assuming that freed labor could be used to return $1.00 an hour in some other use, the additional jobs that could be profitably hired would include plowing, harrowing, and cultivation of corn (Table 15). These and the jobs mentioned above are not performed in a regular work sequence and there is some latitude

Table 15. — Equipment Combination and Annual Cash Costs for Equipment Services When Part of the Cropping Equipment Is Owned and Part Is Hired Assuming Farm Labor Has a Value of $1.00 an Hour, Farm A

Operation	Machines		Method of Acquiring Service	Annual Cash Cost
	Number and Kind	Size		
				Dollars
Plowing	1 2-bottom plow	14-inch	Custom	52
Harrowing	1 disk harrow	7-foot	Custom	60
Planting corn	1 planter	2-row	Custom	14
Cultivating corn	1 cultivator	2-row	Custom	48
Spreading manure	1 spreader	70-bu.	Own	149
Spreading fertilizer and lime	1 spreader	8-foot	Own	78
Seeding grass	1 grass seeder	8-foot	Custom	4
Harvesting hay	1 mower	7-foot	Own	74
	1 S.D. rake	9-foot	Own	76
	1 loader and wagon	Standard 4-wheel	Own Own	168
	1 fork, hoist	Standard	Own	55
Harvesting corn silage	1 forage harvester and tractor	Large Medium	Custom Custom	133
	2 trucks	1½-ton	Custom	
	1 blower and tractor	Auger Small	Custom Own	14
Pasture maintenance	1 drag	Brush	Own	9
	1 mower	7-foot	Own	21
General power and transportation	1 tractor	Small	Own	212
	1 truck	½-ton	Own	101
	1 wagon	4-wheel	Own	28
Total				1,296

as to the time when they must be done. Total costs for operating and owning other cropping machinery and for the custom work hired for the six field operations when the hired labor freed through custom hiring is not released would be $1,296 yer year compared with $1,476 if all of the machines were owned (Table 17). This reduction of $180 in total farm costs would result in a decrease of $0.14 per 100 pounds of milk produced and net farm income would be increased by $180 (Table 17).[7] The investment in cropping equipment would be reduced by $2,615, or roughly 36 percent.

Alternative 5 — Partly Owned, Partly Hired, and Custom Work Off the Farm

The limiting factor in the adjustment of doing custom work off the farm (assuming a demand for services), would be the conflict for equipment and labor between the home-farm and custom operations. The proposed crop and

7 If hired labor freed by the hiring of custom services could be released, it would reduce total farm costs by $208 below that incurred with owned machinery. The cost of producing 100 pounds of milk would be reduced $0.17 and net farm income would be increased $180.

livestock systems of farm A are so organized that the labor force is utilized to its seasonal capacity. This means that no adjustments in custom work for other farmers are feasible unless the labor for operating owned equipment off the farm can be freed by hiring some work done on the farm in the same season.

Several good adjustments that would combine some self-ownership, hiring some custom work, and providing some custom work are possible within the framework of farm A. Through the hiring of certain custom services, the labor freed could be utilized in providing services to other farmers with different machines. Under actual conditions, the particular combination of machines would depend on the supply of custom services in the neighborhood as well as on the demand for particular services. It would also be influenced by the desires of the farm operator and by his individual capabilities. Consequently, only a few of the better alternative adjustments are analyzed here.

If the labor freed could earn a minimum of $1.00 an hour, hiring the plowing and harrowing, the planting, cultivating, and harvesting of corn, and seeding grass, would result in a saving of $180 (Alternative 4) over operating all self-owned equipment (Table 17).[8] Hiring these six operations would save a total of 135 man-hours. If the farmer could utilize this freed time doing custom work for other farmers, he could earn some additional income. An examination of the seasonal distribution of the freed labor indicates that all of the 135 hours, except 28 hours of seasonal hired labor freed by the custom silo-filling operation, could be utilized in doing the custom jobs of spreading fertilizer and manure, and mowing hay. The 28 hours of seasonal hired labor could not be used for doing custom work off the farm, as the farm tractor is used on the farm in combination with the hired custom silo-filling outfit. But it is assumed that this seasonal hired labor freed by the hiring of custom services is not released.

Arbitrarily dividing the 107 hours equally among these jobs, the net returns from the three custom-performed jobs, deducting operating and labor costs, would amount to $225.[9] The original saving of $180 in costs of ownership and operation through custom hiring compared with owning all farm machines is reduced to $129 because of the increased expense involved in doing off-farm custom work. But this complete adjustment, which involves both hiring and doing custom work, increases net farm income by $354 over that obtained by owning all farm machines and doing no custom work (Table 17).[10]

As an alternative, only the planting and harvesting of corn and the seeding of grass might be custom hired and the time thus freed used to increase the work on the other three jobs which were included as custom hired above. In this way, the work load on the three jobs not hired — plowing, harrowing, and corn cultivating — could be increased by doing enough custom work on

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8 The situation which assumes that farm labor is not a cost cannot be tested in this alternative.

9 Dividing the time equally does not assure the highest income as the net returns above operating costs for the various custom jobs are not necessarily the same. For example, manure spreading returns a net of $3.53 per hour and plowing only $2.99 per hour, including a wage of $1.00 an hour. Labor costs are deducted as we have assumed a value of $1.00 an hour for farm labor.

10 If hired labor freed by the hiring of custom services could be released, total farm costs would be reduced $157 while net farm income would be increased $354, compared with owning all farm machines and not doing any custom work. The cost of producing 100 pounds of milk would be reduced by $0.13.

these jobs to justify ownership of machines. Custom hiring the planting and harvesting of corn and the seeding of grass would free 65 hours of the time of the farmer and seasonal hired help which could be used in doing custom plowing, harrowing, and corn cultivating. Again it is assumed that the hired labor freed by the hiring of custom services is not released. Dividing the 65 hours equally among plowing, harrowing, and corn cultivating would increase net returns by $57. Hiring the three operations — planting corn, harvesting corn, and seeding grass — would reduce total machinery operating and ownership costs by $182. The complete adjustment involving both hiring and doing custom work decreases total costs only $137 because of the increased costs incurred by doing custom work off the farm. This complete adjustment, which involves both hiring and doing custom work, increases net farm income by $194 compared with owning all farm machines and doing no custom work (Table 17).[11]

Some of the advantages in income from these two adjustments which combine various ownership patterns is the result of relatively high rates for doing some custom jobs. With increasing competition for custom work this kind of relationship cannot be expected to continue. For that reason care should be taken in analyzing such examples, and too much emphasis should not be placed on the absolute differences in money incomes or costs.

Summary of Alternative Ownership Patterns

Table 16 summarizes the effect of three investments in machinery on farm income, farms costs, and cost of producing milk for the situation in

Table 16. — Comparison of Investment and Costs and Returns for Alternative Patterns of Ownership of Machinery, Assuming Farm Labor Is Not a Cost, Farm A

Ownership Pattern	Investment in Farm Machinery*	Total Ownership and Operating Costs†	Difference Between Complete Ownership and Alternatives		
			Total Farm Costs	Cost of Producing 100 lbs. of Milk	Net Farm Returns
	Dollars	Dollars	Dollars	Dollars	Dollars
Alternative 1 Owned by the operator‡	7,240	950			
Alternative 3 Custom hired§	0	1,480	+530	+0.42	−530
Alternative 4 Partly owned and party custom hired‖	5,250	861	− 89	−0.07	+ 89

*All equipment valued at full 1949 purchase price.
†Includes costs of hiring custom work.
‡See Table 12 for a list of operations.
§See Table 13 for a list of operations.
‖See Table 14 for a list of operations.

11 If hired labor freed by the hiring of custom services could be released, total farm costs would be reduced $165 while net farm income would be increased $194 compared with owning all farm machines and doing no custom work. At the same time the cost of producing 100 pounds of milk would be reduced by $0.13.

which labor freed by adjustments in the pattern of ownership of machinery can be neither productively employed nor removed from the payroll. Of the three ownership patterns listed in Table 16, Alternative 4, partly owned and partly custom hired, would result in the lowest costs and the highest net farm income. With this pattern of ownership, investment in machinery would be reduced by $1,990, or roughly 30 percent below that of entire self-ownership. The cost of complete custom hire, Alternative 3, would increase total costs considerably but would require no capital investment for machinery. It is clear that hiring certain cropping operations done would reduce costs and increase net farm income even though the freed labor could not be released or used productively on the farm.

Table 17 is a similar summary in which it is assumed that the labor freed can be productively employed and that it would earn $1.00 an hour. Four alternative ownership patterns can be appraised when labor is given a value.

Alternative 5 — with machines partly owned, partly hired, and with custom work done off the farm — would result in the largest net farm income.

Table 17. — Comparison of Investment and Costs and Returns for Alternative Patterns of Ownership of Machinery, Assuming Labor Has a Value of $1.00 per Hour and Labor Freed Through Custom Hiring Is Not Released, Farm A*

Ownership Pattern	Investment in Farm Machinery†	Total Ownership and Operating Costs‡	Difference Between Complete Ownership and Alternatives		
			Total Farm Costs	Cost of Producing 100 lbs. of Milk	Net Farm Returns
	Dollars	Dollars	Dollars	Dollars	Dollars
Alternative 1					
Owned by the operator§	7,240	1,476			
Alternative 3					
Custom hired‖	0	1,480	+ 4	0	— 4
Alternative 4					
Partly owned and partly custom hired¶	4,625	1,296	—180	—0.14	+180
Alternative 5					
Partly owned, partly custom hired and custom work off the farm**					
Plan I	4,625	1,347	—129	—0.10	+354
Plan II	5,250	1,339	—137	—0.11	+194

*See text footnote 6, 7, 10, and 11 for description of differences in costs and income when hired labor freed through custom hiring is released.

†All equipment valued at 1949 purchase price.

‡Includes costs of hiring and doing custom work where applicable.

§See Table 12 for a list of operations.

‖See Table 13 for a list of operations.

¶See Table 15 for a list of operations.

** See text, page 23, for a description of operations.

It would not result in the lowest cost of production per unit, although costs would be reduced. Investment in machinery with Plan I of this pattern of ownership would be as low as with Alternative 4, self-ownership and custom-hired, but with Plan II it would be slightly higher. Alternative 5 illustrates the effect on income of increased specialization of machinery. Ownership of certain machines would be avoided by custom hiring. With the labor freed, custom work could be done with some of the remaining equipment owned by the farmer. Thus the workload for the farm labor force would remain the same.

The relative influence of different adjustments on costs and net farm income is noteworthy. Lowest costs per unit are not necessarily associated with the highest net farm income. This analysis points out the fallacy, from the viewpoint of individual farmers, of emphasizing too much the costs of production.

Farm B — A Medium-sized Dairy Farm

As operated, farm B is a 26-cow dairy farm with 18 youngstock and a bull. Cropland consists of 69 acres: 7 in corn silage, 6 in new seeding, 5 in improved rotation pasture, and 51 in mixed hay. There are 120 acres of permanent pasture and pastured woods. The combination of equipment is built around a medium-sized tractor and a 1½-ton platform truck. Two horses and some horse equipment are also maintained. Adjustments suggested for this farm in the earlier report indicate that more intensive use of existing resources would produce a greater size of business without increasing the workload if suggested managerial techniques were followed.[12] Under the revised plan the output of both crops and livestock would reflect improved management. Some shifts were made in use of cropland although no land was added. A small additional net investment was needed for some changes in buildings and equipment.

Table 18. — Suggested Crop and Livestock Organization of Farm B, a Typical Medium-sized New England Dairy Farm

Crop	Acres	Production in Tons of Hay Equivalent
Corn silage	7	35
Hay*	40	92
New seeding	8	16
Aftermath grazing	(40)	8
Rotation pasture	14	31
Permanent pasture	40	40
Total	109	222

Livestock	Number	Production	
Cows	34	Milk produced	231,900 lbs.
Heifers, 1 year+	7	Cows sold	7 head
Heifer calves	8	Calves sold	21 head
Bull	1		

*All hay land harvested twice.

12 I. F. Fellows, G. E. Frick, and S. B. Weeks, op. cit.

The revised cropping and livestock plan outlined in Table 18 was used as a basis for testing alternative patterns of machinery and equipment organization. As with the small farm, only the aspects of the farm business associated with the use of machinery and equipment were analyzed in detail. Estimates were made of the effects of alternative equipment patterns upon additional farm costs and additional farm returns.

The cropping operations showing both crop acres and acres of work are given in Table 19.

Table 19. — Annual Acreage Associated with Cropping Operations, Farm B

Operation	Acres of Land	Acres of Work
Plowing	18	18
Harrowing	18	36
Planting corn	7	7
Cultivating corn	7	28
Spreading manure	45	45
Spreading fertilizer and lime	56	76
Seeding grass	11	11
Harvesting hay	40	80
Harvesting corn silage	7	7
Pasture maintenance	54	54

Alternative 1 — Recommended Combination of Self-owned Equipment

The crop programs and cropping operations for farms A and B are similar and the proportions of the total number of acres of work in various jobs is practically the same. The major difference is that farm B has considerably more crop acreage. To compensate for the larger acreage, the tractor is medium-sized, the truck 1½ ton, the breaking plow has two 14″ bottoms, and the wagon is omitted. The total job hours of machine work on farm B are a third greater than on farm A with 2 acres more corn silage, 30 acres more hay and rotation pasture, 3 acres more new seedings, and 10 acres more pasture.

The combination consisting of all owned equipment for farm B is shown in Table 20. This represents the optimum combination of mechanically powered machinery that would meet the functional requirements of the farm cropping program with the existing supply of labor. Direct operating costs of this combination of machinery with no charge for labor amounted to $363 per year and total machinery costs amounted to $1,348 per year.

Alternative 2 — Joint Ownership

Joint ownership would permit reduction of costs of production by lowering annual ownership costs roughly by half. But on farms of this size the workload per machine is probably large enough for the loss of timeliness of operation to offset the advantages of lower ownership costs. Evaluation of this alternative method as an opportunity to reduce production costs must be related to the circumstances of each situation.

Alternative 3 — Substitution of Custom-hired for Self-owned Machinery

Substituting custom-hired for owned machinery in performing all of the field operations would require a cash payment of $3,196 on farm B.

Table 20. — Investment, Costs, and Time Requirements for a Recommended Combination of Owned Crop Machinery for Farm B When All Work Is Self-performed

Operation	Machines		Hours of Machine Operation	Man-hours of Operating Labor	Price at Local Dealer	Ownership Costs	Total Ownership and Operating Costs with Specified Value per Hour for Labor*	
	Number and Kind	Size					None	$1.00
			Hours	Hours	Dollars	Dollars	Dollars	Dollars
Plowing	1 plow, 1-way	2 14-inch	23	23	160	23	36	59
Harrowing	1 disk harrow	7-foot	43	43	200	29	54	97
Planting corn	1 planter	2-row	7	7	225	22	26	33
Cultivating corn	1 cultivator	2-row	22	22	225	28	40	62
Spreading manure	1 spreader	70-bu.	45	148	375	66	92	240
Spreading fertilizer and lime	1 spreader	8-foot	61	76	150	22	56	132
Seeding grass	1 seeder	8-foot	4	4	175	20	22	26
Harvesting hay	1 mower	7-foot	56	56	250	33	67	123
	1 S.D. rake	9-foot	48	48	300	41	70	118
	1 loader	Standard	72	144	325	44	48	271
	1 truck	1½-ton			†	†	79	
	1 fork, hoist	Standard	16	80	150	17	25	105
Harvesting corn silage	1 corn binder	1-row	14	16	750	73	81	97
	1 ensilage cutter	12-inch	21	22	490	63	119	141
	1 aux. eng.	15-H.P.			350	46		
	1 truck	1½-ton	14	56	†	†	15	71
Pasture maintenance	1 drag	Brush	11	11		1	7	18
	1 mower	7-foot	38	38	‡	‡	23	61
General power and transportation	1 tractor	Medium	30	30	1800	217	232	262
	1 truck	1½-ton	15	15	2000	240	256	271
Total			540	839	7925	985	1348	2187

*Includes operating cost of tractor for all tractor-powered machines.

†Price and ownership cost of the truck are not allocated to the various crop operations.

‡Price and ownership cost of the mower are included with the hay harvesting operation.

This substitution would cost $1,848 more than the ownership and operating costs for owned machinery if no value is placed on the labor of the farm operator, but only $1,009 more if this labor is valued at $1.00 an hour and freed hired labor is not released.[13] In both cases the substitution of custom services would relieve the operator of a capital investment of $7,925 at new machinery prices in 1949.

Alternative 4 — Partly Owned and Partly Hired

If the farm labor freed by custom work is assumed to have no value, it would be profitable to custom hire the same operations as were suggested for the small dairy farm — planting and harvesting corn, and seeding grass. Total machinery costs for the cropping program would be $1,253 a year — a saving of $95 when compared with all self-owned equipment. Capital investment in cropping machinery would be reduced by $1,990, or about 25 percent.

If the labor on farm B had a value of $1.00 an hour and the hired labor freed by the hiring of custom services could not be released, the same three jobs mentioned above and plowing could be custom hired profitably. Total cash costs for cropping machinery would be $2,032 a year compared with $2.187 if all the machines were owned.[14] The investment in cropping equipment would be $2,150 below that for complete ownership, or about 27 percent.

Alternative 5 — Partly Owned, Partly Custom Hired, and Custom Work Off the Farm

Several arrangements are possible in combining self-ownership, hiring custom work, and providing custom services. But only two possibilities are discussed.

In the analysis of Alternative 4 when labor has a value, hiring four cropping operations — plowing, planting corn, seeding grass, and harvesting corn — would free a total of 115 hours. But 26 hours of hired seasonal labor in this total cannot be used for doing custom work off the farm because the farm tractor and farm operator would be helping the custom operator to fill the silo. This leaves a total of 89 hours free at a time when some custom work could be performed off the farm. Arbitrarily dividing this custom among corn cultivating, harrowing, and mowing would result in an increase of $140 in income, after deducting labor and operating costs. Total ownership and operating costs would be reduced $103 compared with self-ownership of equipment. Assuming that the 26 hours of freed hired labor is not released but is used productively on the farm, the complete adjustment involving both hiring and doing custom work would increase net farm income by $295 compared with entire ownership.[15]

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13 If hired labor freed by the hiring of custom services could be released, it would cost $889 more to custom-hire all crop work than to do it with owned machinery. The cost of producing 100 pounds of milk would be increased by $0.38 and net farm income would remain the same whether or not the labor was used on the farm or released.

14 If hired labor freed by the hiring of custom services could be released, cash costs would be $2,006 a year compared with $2,187 if all the machines were owned. The cost of producing 100 pounds of milk would be reduced by $0.08 and net farm income would be increased by $155.

15 If hired labor freed by the hiring of custom services was released, total farm costs would be reduced $129 and net farm income would be increased $295 compared with owning all farm machines and doing no custom work. The cost of producing 100 pounds of milk would be reduced by $0.06.

As a second possibility, only the seeding of grass and the harvesting of corn would be hired. Custom jobs done off the farm would be plowing, harrowing, and planting and cultivating corn. The custom-hired jobs of seeding grass and harvesting of corn would free 85 hours of labor, of which 26 hours is seasonal hired help that could not be used for doing custom work. The remaining 59 hours of operator labor would be equally divided among the four off-farm custom operations. Assuming that the 26 hours of freed hired labor is still employed and used on the farm, the complete adjustment involving hiring and doing custom work would result in an increase in net farm income of $241, compared with entire ownership. Total ownership and operation costs would be reduced by $107 compared with self-ownership of equipment.[16]

Summary of Alternative Ownership Patterns

The results for farm B are similar to those for farm A. Of the three ownership patterns compared in Table 21, in which labor is assumed to have no other productive employment, Alternative 4 (partly owned and partly custom hired) would result in the lowest cost and the highest net income. Investment in machinery would be reduced also. Substitution of complete custom hiring for self-owned machinery avoids investment in machinery but increases total costs considerably.

Table 21. — Comparison of Investment and Costs and Returns for Alternative Patterns of Ownership of Machinery, Assuming Farm Labor Is Not a Cost, Farm B

Ownership Pattern	Investment in Farm Machinery*	Total Ownership and Operating Costs†	Difference Between Complete Ownership and Alternatives: Total Farm Costs	Difference Between Complete Ownership and Alternatives: Cost of Producing 100 lbs. of Milk	Difference Between Complete Ownership and Alternatives: Net Farm Income
	Dollars	Dollars	Dollars	Dollars	Dollars
Alternative 1 Owned by the operator‡	7,925	1,348			
Alternative 3 Custom hired§	0	3,196	+1,848	+0.80	−1,848
Alternative 4 Partly owned and partly custom hired‖	5,935	1,253	− 95	−0.04	+ 95

*All equipment valued at full 1949 purchase price.

†Includes costs of hiring custom work.

‡See Table 20 for a list of operations.

§The same group of operations were compared as in Table 20.

‖See text, page 30, for a description of operations.

16 If hired labor freed by the hiring of custom services were released, total farm costs would be reduced $133 and net farm income increased $241 compared with entire ownership. The cost of producing 100 pounds of milk would be decreased $0.06.

In the summary in Table 22 it is assumed that the labor freed can be productively employed and that it would earn $1.00 an hour. Alternative 5 (self-ownership, custom hiring, and custom work off the farm) would result in the highest net farm income. But this alternative would not produce the lowest costs per unit of production, although costs would be reduced.

Table 22. — Comparison of Investment and Costs and Returns for Alternative Patterns of Ownership of Machinery, Assuming Labor Has a Value of $1.00 an Hour and Labor Freed Through Custom Hiring Is Not Released, Farm B*

Ownership Pattern	Investment in Farm Machinery†	Total Ownership and Operating Costs‡	Difference Between Complete Ownership and Alternatives		
			Total Farm Costs	Cost of Producing 100 lbs. of Milk	Net Farm Income
	Dollars	Dollars	Dollars	Dollars	Dollars
Alternative 1					
Owned by the operator§	7,925	2,187			
Alternative 3					
Custom hired‖	0	3,196	+1,009	+0.44	—1,009
Alternative 4					
Partly owned and partly custom hired¶	5,775	2,032	— 155	—0.07	+ 155
Alternative 5					
Partly owned, partly custom hired, and custom work off the farm**					
Plan I	5,775	2.084	— 103	—0.04	+ 295
Plan II	6,160	2,080	— 107	—0.05	+ 241

*See text footnotes 13, 14, 15, and 16 for description of differences in costs and income when hired labor freed through custom hiring is released.

†All equipment valued at 1949 purchase price.

‡Includes costs of hiring and doing custom work where applicable.

§See Table 20 for a list of operations.

‖The same groups of operations were compared as in Table 20.

¶See page 30, for a description of operations.

**See page 30, for a description of operations.

Farm C — A Large Dairy Farm

Farm C as operated contains 90 acres of cropland, 130 acres of unfertilized permanent pasture, and some woods and wasteland. A 36-cow herd and 14 head of other dairy stock are kept. The livestock program requires a crew of two men. During the cropping period an additional four months of labor is hired. The farm is equipped with a medium-sized and small tractor, and a farm truck of 1½-ton capacity. A complete line of tractor implements is available.

The reorganization suggested in the earlier report was built around a revision in hay-harvesting methods and barn chore work.[17] Both of these adjustments would require considerable capital. The major improvement in barn chore work would be the installation of a gutter cleaner. Cropping operations would involve a shift to grass silage and investment in a field forage chopper and associated equipment. There were also suggestions for a general intensification of the livestock and cropping programs through shorter rotations, increased levels of fertilization, and better management of the herd. Through the improvement in quality of roughage, some increase in production of milk would occur.

Table 23. — Suggested Crop and Livestock Organization of Farm C, a Typical Large New England Dairy Farm

Crop	Acres	Production in Tons of Hay Equivalent
Hay and grass silage		
Hay land*	65	162
New seeding†	15	8
New seeding grazed	(15)	12
Rotation pasture	10	23
Permanent pasture	70	84
Total	160	289

Livestock	Number	Production	
Cows	40	Milk produced	272,800 lbs.
Heifers, 1 year+	8	Cows sold	8 head
Heifer calves	8	Calves sold	24 head
Bull	1		

*All land harvested 3 times.
†Harvested 1 time.

The revised cropping and livestock plan outlined in Table 23 was used as a basis for testing alternative patterns of machinery and equipment organization. As with the small and medium-sized farms, only the aspects of the farm business associated with the use of machinery and equipment were analyzed in detail. Estimates were made of the effect of the alternative patterns of ownership upon farm costs and additional farm returns.

Cropping operations showing both crop acres and acres of work are given in Table 24.

Alternative 1 — Self-owned Equipment

The crop program and cropping operations on farm C differ considerably from those on farms A and B in that grass silage is substituted for corn silage. This shift reduces the proportion of total acres associated with the work of plowing and harrowing. But it increases the proportion of total acres of work associated with pasture maintenance and with the hay and

17 I. F. Fellows, G. E. Frick, and S. B. Weeks, op. cit.

Table 24. — Annual Acreages Associated with Cropping Operations, Farm C

Operation	Acres of Land	Acres of Work
Plowing	10	10
Harrowing	10	20
Spreading manure	55	55
Spreading fertilizer and lime	87	97
Seeding grass	10	10
Harvesting hay and grass silage	75	145
Pasture maintenance	120	130

grass-silage crops. Nevertheless, much of the foundational equipment is common to the three farms. The major changes in equipment on farm C center on a shift from machinery for cultivating and harvesting corn to a field forage harvester with its associated equipment. A second tractor would be added also.

The combination of all owned equipment for farm C is shown in Table 25. This represents the optimum combination of mechanically powered machinery that would meet the functional requirements of the farm cropping program and the labor supply. Direct operating costs of this combination of machinery with no charge for labor would amount to $506 a year and total costs of machinery to $1,773 a year.

Alternative 2 — Joint Ownership

Joint ownership is not particularly well adapted to farms of this size. Even though annual ownership costs would be reduced roughly by half, the competition for the use of equipment probably would be too intense if two farms the size of farm C were to share all of it. Some machines of the type not used in timely crop production might be shared by two farms with no change in the quantity or quality of the roughage program. Such arrangements between farmers for one or more machines would contribute to decreasing costs of production.

Alternative 3 — Substitution of Custom-hired for Self-owned Machinery

Substitution of custom-hired for self-owned machinery for performing all of the field operations would require an annual cash payment of $3,241. With no value for farm labor, the annual cost would be $1,468 more than Alternative 1, and if labor were valued at $1.00 an hour, it would cost $627 more than Alternative 1. However, on farm C there is an opportunity to release four months of hired seasonal labor. Custom-hiring all cropping work and not hiring this seasonal labor would cost $53 less than doing all the work with self-owned equipment.[18] In both cases the substitution of custom services would eliminate the need for an investment of $9,325 in farm machinery at new machinery prices in 1949.

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18 If hired labor freed by the hiring of custom services could be released, the cost of producing 100 pounds of milk would be reduced by $0.02. However, net farm income would be reduced by $627.

Table 25. — Investment, Costs, and Time Requirements for a Recommended Combination Owned Crop Machinery for Farm C When All Work Is Self-performed

Operation	Machines		Hours of Machine Operation	Man-hours of Operating Labor	Price at Local Dealer	Ownership Costs	Total Ownership and Operating Costs with Specified Value per Hour for Labor*	
	Number and Kind	Size					None	$1.00
			Hours	Hours	Dollars	Dollars	Dollars	Dollars
Plowing	1 plow, 1-way	2 16-inch	12	12	200	27	35	47
Harrowing	1 disk harrow	7-foot	20	20	200	29	40	60
Spreading manure	1 spreader	70-bu.	72	88	375	66	114	202
Spreading fertilizer and lime	1 spreader	8-foot	78	97	150	22	66	163
Seeding grass	1 grass seeder	8-foot	4	4	175	20	22	26
Harvesting hay and grass silage	1 mower	7-foot	102	102	250	33	105	207
	1 S.D. rake	9-foot	87	87	300	41	94	181
	1 field chopper	Aux. eng.	102	102	2400	387	494	596
	2 wagons	4-wheel	203	102	†	†	63	165
	2 unloaders	1/3-H.P.	72		150	22	28	
	1 blower	Auger	72	116	275	36	115	259
	1 aux. eng.	15-H.P.	72		350	46		
Pasture maintenance	1 drag	Brush	12	12		1	7	19
	1 mower	7-foot	49	49	‡	‡	35	84
General power and transportation	1 tractor	Large	15	15	2200	264	273	288
	1 tractor	Medium	15	15	1800	217	225	240
	2 wagons	4-wheel	20	20	500	56	57	77
Total			1007	841	9325	1267	1773	2614

*Includes operating cost of tractor for all tractor-powered machines.
†Price and ownership cost of the wagons are not allocated to the harvesting operation.
‡Price and ownership cost of the mower is included with the hay-harvesting operation.

Alternative 4 — Partly Owned and Partly Hired

Assuming no value for labor freed through the substitution of custom for self-performed jobs, it would be profitable to hire only the seeding of grass done on a custom basis. This would result in savings of only $14 and machinery investment would be reduced by only $175, or 2 percent. The workload for the machines on farm C is large enough so that hiring only the grass seeded would be profitable even if freed labor is valued at $1.00 an hour. The total investment in machinery would be reduced by only 2 percent and total machinery costs by $20.[19]

Alternative 5 — Partly Owned, Partly Custom Hired, and Custom Work Off the Farm

The profitable hiring of only one cropping job, with either wage assumption, under Alternative 4 limits the alternatives that could be developed for doing custom work off the farm. Custom-hiring grass seeding done frees only four hours of permanent labor. Assuming that custom plowing could be done with the freed labor, the complete adjustment involving both the hiring of grass seeding done and doing custom plowing would increase net farm income by $31 and decrease total machinery costs by $17.[19]

Summary of Alternative Ownership Patterns

Table 26 summarizes the effect of the various ownership patterns on farm income and costs when labor freed because custom hiring is substituted for owned equipment cannot be productively employed on the payroll. Al-

Table 26. — Comparison of Investment and Costs and Returns for Alternative Patterns of Ownership of Machinery, Assuming Farm Labor Is Not a Cost, Farm C, 1949

Ownership Pattern	Investment in Farm Machinery*	Total Ownership and Operating Costs†	Difference Between Complete Ownership and Alternatives		
			Total Farm Costs	Cost of Producing 100 lbs. of Milk	Net Farm Income
	Dollars	Dollars	Dollars	Dollars	Dollars
Alternative 1 Owned by the operator‡	9,325	1,773			
Alternative 3 Custom hired§	0	3,241	+1,468	+0.54	—1,468
Alternative 4 Partly owned and partly custom hired‖	9,150	1,759	— 14	—0.01	+ 14

*All equipment valued at full 1949 purchase price.
†Includes costs of hiring custom work.
‡See Table 25 for a list of operations.
§The same group of operations were compared as in Table 25.
‖See text, page 36, for a description of operations.

19 The single opportunity for hiring custom work in combination with self-owned equipment frees no hired seasonal labor. Therefore, no effect on costs is associated with releasing or continuing to employ hired labor as on farms A and B.

though the opportunities for profitable custom hiring are limited on farm C, Alternative 4. which combines self-ownership with some custom hiring, would result in the lowest costs and the highest net farm income. This alternative would also reduce the investment in machinery required. Complete custom hiring of all cropping jobs would increase costs considerably, but would have the advantage of eliminating the need for any capital investment in machinery.

Table 27. — Comparison of Investment and Costs and Returns for Alternative Patterns of Ownership of Machinery, Assuming Labor Has a Value of $1.00 an Hour and Labor Freed Through Custom Hiring Is Not Released, Farm C*

Ownership Pattern	Investment in Farm Machinery†	Total Ownership and Operating Costs‡	Difference Between Complete Ownership and Alternatives		
			Total Farm Costs	Cost of Producing 100 lbs. of Milk	Net Farm Income
	Dollars	Dollars	Dollars	Dollars	Dollars
Alternative 1 Owned by the operator§	9,325	2,614			
Alternative 3 Custom hired‖	0	3,241	+ 627	+0.23	— 627
Alternative 4 Partly owned and party custom hired¶	9,150	2,594	— 20	—0.01	+ 20
Alternative 5 Partly owned, partly custom hired and custom work off the farm**	9,150	2,597	— 17	—0.01	+ 31

*See text and text footnotes 18 and 19 for description of differences in costs and income when hired labor freed through custom hiring is released.

†All equipment valued at 1949 purchase price.

‡Includes costs of hiring and doing custom work when applicable.

§See Table 25 for a list of operations.

‖The same groups of operations were compared as in Table 25.

¶See text, page 36, for a description of operations.

**See text, page 36, for a description of operations.

In Table 27 it is assumed that labor freed through the hiring of custom equipment can be productively employed and would earn $1.00 an hour. Complete custom hiring would reduce total costs slightly if the seasonal hired labor could be released. Farm C has few profitable custom-hiring possibilities and this in turn limits the opportunity to do custom work for other farmers. Therefore, total machinery costs and net farm income with Alternatives 1, 4, and 5 would be similar.

Summary and Conclusions

Most New England dairy farms are relatively small in terms of use of farm machines in work on crops. The problems of fitting and adapting modern labor-saving machinery to this type of farm is one of the major farm-management problems in this area. But mechanization on New England dairy farms has proceeded at a rapid rate. With increasing mechanization, established dairymen and young people just getting started in farming must invest heavily in machinery and must carry high annual ownership costs.

Greater mechanization is contributing to the long-time trend in specialization on New England dairy farms through the rise of custom services for performing many operations that involve the use of farm machinery. Hiring certain jobs custom-performed often reduces costs of production and frees capital and labor for use in producing more milk. Many types of machines and services are now available for hire by farmers in New England. These custom services are provided by farmers and by specialized custom operators. However, the bulk of the custom work hired by New England farmers is done by farmer neighbors, who do custom work as a sideline to full-time farming. Frequently, they supply only a single type of service such as baling hay, planting corn, or harvesting forage. Others who operate farms, but who are not fully employed on the farm, do several types of seasonal custom work, such as preparing gardens in spring, mowing and raking hay in summer, and sawing wood and removing snow in fall and winter. In 1949 expenditures for custom work by all types of farms in New England amounted to 5.6 million dollars. Of this total it is estimated that dairy farmers hired about 3.5 million dollars worth of custom work done.

An analysis was made to determine the optimum combinations of equipment and the best ownership patterns for typical 1-man, 2-man, and 3-man dairy farms. This analysis shows that if all field jobs were done by self-owned machines, the optimum combination of equipment would require an investment at 1949 prices of about $7,200 for the small farm, $7,900 for the 2-man farm, and $9,300 for the large farm.

Each of these farms could benefit by hiring certain jobs done rather than using self-owned equipment. The small farm, because of the limited workload for many operations, would benefit most from this adjustment. It could profitably hire several tillage, planting, and harvesting jobs that have some latitude as to the time when they must be done. Opportunities to custom hire profitably would be limited on the large farm.

An additional alternative in patterns of ownership of equipment is to own no field equipment and to custom-hire all cropping operations. This would eliminate the rather substantial investment required in self-owned machinery. But from the viewpoints of cost and income it would be less attractive than the other alternatives on the 2- and 3-man farms. On the small farm complete custom hiring would compare favorably with self-owned equipment if the farm labor freed by custom hiring had an alternative productive use.

The best ownership patterns for all three farms appeared to be a foundation of self-owned equipment with certain jobs hired and certain others done off the farm for neighbors. Such a program would maximize net income

but would not result in the lowest cost of producing milk. The relative advantage of this adjustment would vary by size of farm, being greatest for the small farm and least for the large farm.

Joint ownership of farm machinery by two or more farmers would be a method of reducing costs of investment on each farm, as many of the machines could readily do the work on two or more farms. But this type of ownership is not common in New England. Apparently other problems associated with cooperative ownership and use of farm machines more than offset any economic advantages, except for a few operators who have special aptitudes for cooperation.

It is evident that most dairy farms should be equipped with certain foundational machinery and equipment such as a tractor, manure spreader, and mowing machine. These types of equipment are used in repetitive jobs and often are not suited for custom hiring. For small farms of 18 cows or under, many of the other cropping operations could be profitably hired done at present prices for custom work. For larger farms, opportunities for economically using custom-hired equipment become fewer. But for many jobs, even on larger farms, use of custom-hired machinery and equipment is economical and capital requirements can be materially reduced through their use.

Other Bulletins in the Series on Production Efficiency on New England Dairy Farms

I. *A Preliminary Appraisal of Cost Reduction Opportunities*, I. F. Fellows, G. E. Frick, and S. B. Weeks. Storrs (Connecticut) Agricultural Experiment Station Bulletin 283 (1952).

II. *Economics of Scale in Dairying — An Exploration in Farm Management Research Methodology*, I. F. Fellows, G. E. Frick, and S. B. Weeks. Storrs (Connecticut) Agricultural Experiment Station Bulletin 285 (1952).

III. *An Economic Evaluation of the Barn-finishing Method of Harvesting Hay*, V. E. Ross and I. F. Fellows. Storrs (Connecticut) Agricultural Experiment Station Bulletin 277 (1951).

IV. *Adjustments in the Organization of Machinery and Equipment*, G. E. Frick, S. B. Weeks, and I. F. Fellows. New Hampshire Agricultural Experiment Station Bulletin 407 (1954).